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AN ANALYSIS OF SIX GROUPS OF ZOOPLANKTON IN SAMPLES TAKEN IN 1978/79 AT THE PROPOSED OTEC SITE IN THE EASTERN GULF OF MEXICO OFF TAMPA BAY

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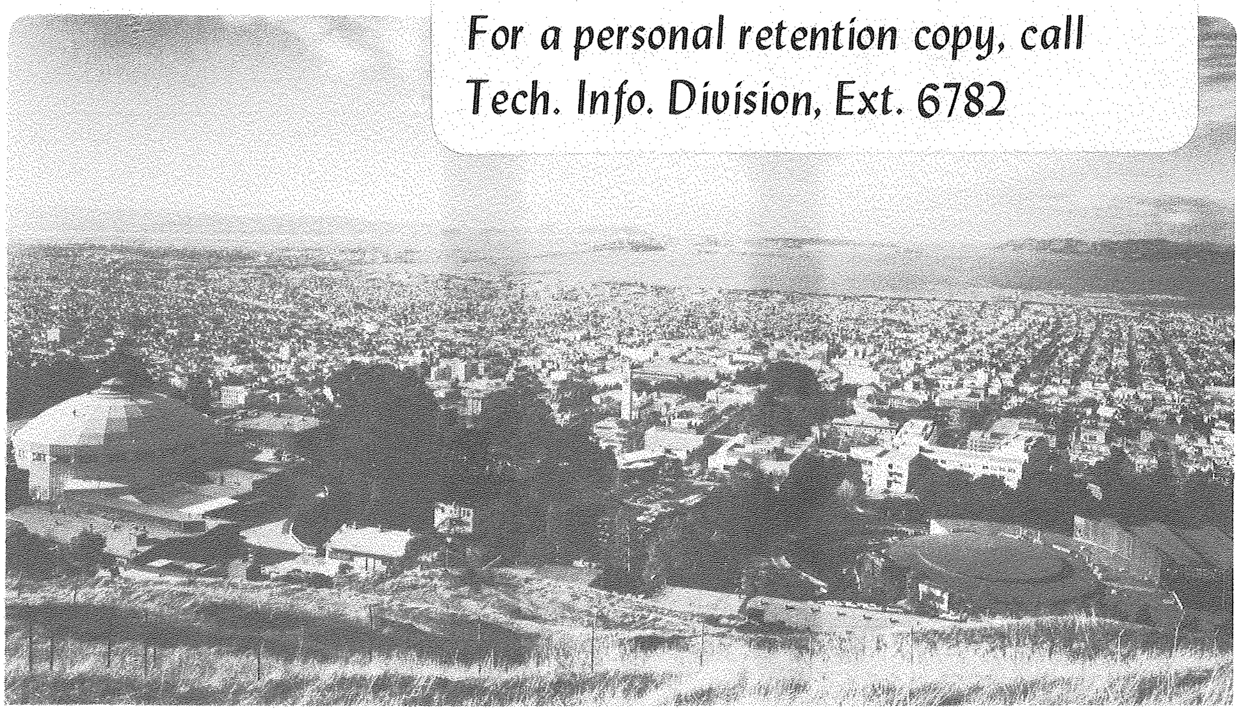

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An analysis of six groups of zooplankton in samples taken in 1978/79 at the proposed OTEC site in the eastern Gulf of Mexico off Tampa Bay

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ABSTRACT

This report is the result of continued analysis of the 33 zooplankton collections made at the proposed OTEC site in the Gulf of Mexico off Tampa Bay. Six groups of zooplankton - siphonophores (Calycophora), pteropods (Thecosomata), chaetognaths, thaliaceans, euphausiids and amphipods were quantitatively investigated. Numbers and biomass were determined for all taxa and diurnal, seasonal and depth trénds were discussed. Considering the present study and the previous investigation of the copepod population, this proposed OTEC site is probably one of the faunistically better known locales in the Gulf of Mexico and Caribbean.

INTRODUCTION

In an earlier series of reports to the Lawrence Berkeley Laboratory we described the copepod fauna and general characteristics of plankton populations at the proposed OTEC site in the Gulf of Mexico off Tampa Bay. In this report we concentrate on six of the remaining groups of zooplankton, providing data on their species composition and seasonal/ vertical abundance. The groups considered are siphonphores (calycophorans) pteropods (thecosomates), chaetognaths, thaliaceans, euphausiids and amphipods. While these groups in combination with the previously analyzed copepods account for the overwhelming share of plankton numbers and biomass as determined from net collections, several important groups remain to be done, e.g., larvaceans and ostracods. Even considering that taxonomic work remains incomplete, the information available from this set of OTEC samples is perhaps the most comprehensive for any single location in the Gulf and Caribbean.

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METHODS

The 33 samples analyzed here were those taken on 7 cruises in 1978-79 to the proposed Gulf of Mexico OTEC site at 27.5°N, 85.5°W. These samples were previously examined for copepods and the study has been extended here to include six additional groups, calycophoran siphonophores, thecosomatous pteropods, chaetognaths, thaliaceans, euphausiids and amphipods. Because of the quantity of zooplankton in each collection it was necessary to subsample, this being done with a Motoda sample-splitting box (Motoda, 1959). In the richer collections 100 of each of the six groups were sorted into aliquots. In sparse samples all of the specimens of each group available in half the total sample were sorted, this often totalling less than 100 individuals per group. Animals were identified using both a microscope and stereo-dissecting scope, and the appropriate taxonomic literature. The major references were:

Siphonophores: Totton and Bergmann (1965); Yamaji (1972)

Pteropods: Tesch (1947); Van der Spoel (1967)

Thaliaceans: Fraser (1947); Thompson (1948)

Euphausiids: Boden, Johnson and Brinton (1955); James (1970); Gopalakrishnan (1975)

Amphipods: Stephensen (1918, 1924, 1925); Chevreux and Fage (1925); Dick (1970)

Chaetognaths: Fraser (1957); Alvarino (1969)

Maximum dimensions were measured of each identified individual and biomass was determined using length-weight regressions as described in Hopkins (1971), and Hopkins and Baird (in press). Also sex and stage of development (i.e., adult male and female, and juveniles) were recorded for euphausiids and amphipods while siphonophore individuals were identified as anterior or posterior nectophores of either polygastric or eudoxoid life stages (see Appendix tables in a separate volume).

RESULTS

Siphonophora (Calycophora). The most prevalent siphonophore group in the OTEC collections was the *Calycophora*. Eleven types were identified to species and these are listed in Table 1. Considering the 1000 m water column and averaging over the period of study, *Eudoxoides mitra* was the most abundant species. Other species exceeding 5% of the siphonophore numbers were *Bassia bassensis* (11.0%), *Eudoxoides spiralis* (10.0%), *Diphyes bojani* (9.8%) and *Abylopsis eschscholtzii* (8.6%). In terms of biomass *D. bojani, E. mitra* and *Diphyes dispar* were the top three species, constituting respecively, 19.3%, 13.2% and 8.7% of the calycophoran biomass. It should be noted that a significant fraction of the biomass (18.8%) was composed of material unidentified to species. The data on biomass may have more value than the numerical estimates because calycophoran colonies were usually fragmented in net catches and the counts here are for total individual nectophores. Counts for each type of nectophore are in the Appendix tables.

In Table 2 are the abundance data by cruise. Thirteen of the 14 categories listed were most abundant either in June, 1978 or February 1979 collections. It is uncertain, however, whether or not this represents any sort of a bimodal seasonal pattern because of the relatively small volume of water filtered on each cruise and the lack of replicates. Except for *Abyla* spp. and possibly *Abylopsis* spp., there is little evidence for diel vertical migration in this group at least in the 0-25 m layer (Table 3). Four taxa were not found in the 0-25 m zone at all (*Enneagonum hyalinum, Lensia fowleri, Lensia* spp. and *Muggiaea* spp) whereas all species were more prevalent in the epipelagic zone (0-200 m) during the day than in the deeper layers sampled (i.e., 200-800 m, 800-1000 m).

Table 1. Average abundance of calycophoran siphonophore species in the upper 1000 m at the OTEC station off Tampa Bay. + = <1 mg or <0.1%

Taxon	No./m^2	%	mg dry wt/m^2	%
Eudoxoides mitra	51.4	16.1	26	13.2
Bassia bassensis	35.2	11.0	6	3.1
Eudoxoides spiralis	32.0	10.0	10	5.1
Diphyes bojani	31.4	9.8	38	19.3
Abylopsis eschscholtzii	27.4	8.6	10	5.1
Lensia spp.	18.4	5.8	14	7.1
Abylopsis tetragona	14.8	4.6	9	4.6
Diphyes dispar	9.0	2.8	17	8.7
Chelophyes appendiculata	5.0	1.6	9	4.6
Abyla spp.	3.0	0.9	15	7.6
Enneagonum hyalinum	1.2	0.4	2	1.0
Muggiaea spp.	1.2	0.4	2	1.0
Abylopsis spp.	0.8	0.3	+	+
Ceratocymba leuckartii	0.4	0.1	1	0.5
Lensia fowleri	0.4	0.1	+	+
Unident. calycophorans	87.8	27.5	37	18.8

Table 2. Abundance of species of calycophoran siphonophores under a square meter for the upper 1000 m for individual cruises to the OTEC site.

Taxon	June 1978	August 1978	December 1978	February 1979	April 1979
Abyla spp.	0	0	2	13	0
Abylopsis eschscholtzii	48	36	10	39	4
A. tetragona	4	5	8	49	2
Abylopsis spp.	0	0	0	0	4
Bassia bassensis	40	4	19	29	14
Ceratocymba leukartii	0	0	1	1	0
Chelophyes appendiculata	8	2	0	15	0
Diphyes bojani	42	6	19	88	2
D. dispar	12	12	4	15	2
Enneagonum hyalinum	2	0	0	4	0
Eudoxoides mitra	48	29	19	100	0
E. spiralis	55	18	18	61	23
Lensia fowleri	0	2	0	0	0
Lensia spp.	28	4	10	36	13
Muggiaea spp.	6	0	0	0	0
Unident. calycophorans	127	75	67	115	55

Table 3. Abundance of calycophoran siphonophore species per $10^4 m^3$ and under a square meter for the upper 1000 m for the period June 13, 1978 to April 29, 1979, excluding October 26, 1978 data.

Taxon	Night 0-25m	Day 0-25m	Day 0-200m	Day 200-800m	Day 800-1000m	Day $\#/m^2$
Abyla spp.	4968	0	156	0	0	3.0
Abylopsis eschscholtzii	4196	10778	1146	12	12	27.4
Abylopsis tetragona	1036	3918	580	42	0	14.8
Abylopsis spp.	250	0	44	0	0	0.8
Bassia bassensis	15248	25518	968	6	6	35.2
Ceratocymba leukartii	24	116	12	2	0	0.4
Chelophyes appendiculata	360	1026	234	7	0	5.0
Diphyes bojani	12022	11924	1496	28	0	31.4
Diphyes dispar	782	818	394	8	10	9.0
Enneagonum hyalinum	0	0	44	6	0	1.2
Eudoxoides mitra	1242	348	1706	60	68	51.4
Eudoxoides spiralis	14668	20098	1092	138	166	32.0
Lensia fowleri	0	0	0	6	0	.4
Lensia spp.	0	0	618	94	20	18.4
Muggiaea spp.	0	0	60	0	0	1.2
Unident. calycophorans	6166	21760	2718	354	40	76.4

Pteropoda (Thecosomata). Twenty species of Thecosomatous pteropods were identified (Table 4), the most abundant species in the upper 1000 m being *Limacina inflata* (18.5% of total numbers of pteropods). The genus *Limacina* was, in fact, the overwhelmingly dominant category constituting 85.3% of the shelled pteropod population. The only other taxon to individually account for over 3% of the catch was *Creseis virgula* f. *virgula* (4.1%). In terms of biomass the top four categories were *Limacina* spp. (30.4%), *L. inflata* (17.4%), *Cymbulia* spp (11.6%) and *Diacria tridentata* (4.3%). Among the 20 species there appeared no consistent seasonal pattern (Table 5). Of the more common species *C. virgula* f. *virgula* had a rather uniform level of abundance from cruise to cruise whereas the other species were temporally more irregular, often being too scarce to be counted in aliquots. Diel vertical migration was apparent in some species but not others (Table 6). For example, the genus *Limacina* in general tended to be more prevalent in the upper 25 m at night than during the day. Other possible migrators were *C. virgula* f. *virgula* and *Styliola subula*, though small sample size makes this uncertain. A potential reverse migration pattern was apparent in *Cavolinia inflexa* which was more abundant in 0-25 m day collections than in night collections. All but a few species were clearly more abundant in the epipelagic zone (upper 200 m) than at depth. Only members of the genus *Clio (C. cuspidata* and *C. pyramida)* occurred exclusively in collections from below 200 m.

Table 4. Average abundance of shelled pteropod species in the upper 1000 m at the OTEC station off Tampa Bay. + = <1 mg

Taxon	No./m^2	%	mg dry wt/m^2	%
Limacina spp.	279.2	61.9	21	30.4
L. inflata	83.4	18.5	12	17.4
Creseis virgula f. *virgula*	18.4	4.1	3	4.3
Limacina retroversa	11.4	2.5	1	1.4
Cavolinia inflexa	9.0	2.0	2	2.9
Peraclis spp.	8.2	1.8	1	1.4
Limacina leseuri	5.8	1.3	1	1.4
Diacria tridentata	5.6	1.2	3	4.3
Creseis virgula f. *conica*	5.4	1.2	2	2.9
Diacria guadridentata	3.4	0.8	+	<1.0
Limacina trochiformis	2.8	0.6	+	<1.0
Peraclis reticulata	2.6	0.6	+	<1.0
Unident. Euthecosomata	2.4	0.5	5	7.2
Diacria trispinosa f. *minor*	2.2	0.5	1	1.4
Limacina bulimoides	1.8	0.4	+	<1.0
Unident. Pseudothecosomata	1.8	0.4	+	<1.0
Diacria spp.	1.8	0.4	1	1.4
Styliola subula	1.4	0.3	+	<1.0
Creseis acicula	1.0	0.2	+	<1.0
Cavolinia longirostris	0.8	0.2	3	4.3
Cuvierina columnella	0.8	0.2	+	<1.0
Cymbulia spp.	0.8	0.2	8	11.6
Clio cuspidata	0.4	0.1	+	<1.0
C. pyramidata	0.4	0.1	+	<1.0
Hyalocyclis striata	0.4	0.1	+	<1.0
Peraclis bispinosa	0.4	0.1	1	1.4

Table 5. Abundance of shelled pteropod species under a square meter for the upper 1000 m for individual cruises to the OTEC site.

Taxon	June 1978	August 1978	December 1978	February 1979	April 1979
Euthecosomata					
Cavoliniidae					
Cavolinia inflexa	8	23	0	14	0
C. longirostris	0	4	0	0	0
Clio cuspidata	0	1	0	1	0
C. pryamidata	2	0	0	0	0
Creseis acicula	0	0	0	3	2
C. virgula f. *conica*	8	9	10	0	0
C. virgula f. *virgula*	16	24	10	21	25
Cuvierina columnella	0	0	1	3	0
Diacria quadridentata	2	2	11	2	0
D. trispinosa	18	0	10	0	0
D. trispinosa f. *minor*	0	9	0	2	0
Diacria spp.	0	0	5	4	0
Hyalocyclis striata	0	2	0	0	<1
Styliola subula	0	2	3	2	0
Cavoliniidae (unident.)	2	0	0	5	3
Limaciniidae					
Limacina bulimoides	0	4	1	2	2
L. inflata	47	33	271	53	13
L. leseuri	0	4	17	8	0
L. retroversa	40	0	13	0	4
L. trochiformes	0	14	0	0	0
Limacina spp.	524	298	400	72	102
Pseudothecosomata					
Peracliidae					
Peraclis bispinosa	0	0	1	<1	1
P. reticula	11	0	0	0	<1
Peraclis spp.	14	12	4	2	16
Cymbuliidae					
Cymbuliidae (unident.)	0	14	0	0	0

Table 6. Abundance of shelled pteropod species per $10^4 m^3$ and under a square meter for the upper 1000 m for the period June 13, 1978 to April 29, 1979, excluding October 26, 1978 data.

Taxon	Night 0-25m	Day 0-25m	Day 0-200m	Day 200-800m	Day 800-1000m	Day $\#/m^2$
Euthecosomata						
Cavoliniidae						
Cavolinia inflexa	1204	2678	426	6	6	9.0
C. longirostris	0	0	44	0	0	0.8
C. longirostris f. *longirostris*	0	38	0	0	0	0.0
Clio cuspidata	0	0	0	2	6	0.4
C. pyramidata	0	0	0	6	0	0.4
C. pyramidata f. *lanceolata*	94	0	0	0	0	0.0
Creseis acicula	644	268	52	0	0	1.0
C. virgula f. *conica*	94	194	268	0	0	5.4
C. virgula f. *virgula*	6660	2782	1560	34	6	18.4
Creseis spp.	2214	0	0	0	0	0.0
Cuvierina columnella	0	0	22	2	10	0.8
Diacria quadridentata	268	332	120	12	10	3.4
D. trispinosa	288	104	260	10	20	6.4
D trispinosa f. *minor*	0	78	90	6	0	2.2
Diacria spp.	0	200	104	0	0	1.8
Hyalocyclis striata	218	48	0	6	4	0.4
Styliola subula	662	0	0	16	10	1.4
Limaciniidae						
Limacina bulimoides	1318	94	86	4	0	1.8
L. inflata	37764	1864	864	852	748	83.4
L. leseuri	828	462	1624	18	10	5.8
L. retroversa	966	0	576	0	0	11.4
L. trochiformes	3892	838	134	0	6	2.8
Limacina spp.	30140	13018	11588	620	508	279.2
Peracliidae						
Peraclis bispinosa	122	0	0	4	2	0.4
P. reticula	216	0	90	8	8	2.6
Peraclis spp.	2566	2434	334	50	26	8.2

Table 6 (Cont'd.). Abundance of shelled pteropod species per $10^4 m^3$ and under a square meter for the upper 1000 m for the period June 13, 1978 to April 29, 1979, excluding October 26, 1978 data.

Taxon	Night 0-25m	Day 0-25m	Day 0-200m	Day 200-800m	Day 800-1000m	Day $\#/m^2$
Cavoliniidae	0	6238	0	6	8	0.8
Euthecosomata (unident.)	1216	0	52	4	18	2.4
Pseudothecosomata						
Cymbulia spp.	0	0	44	0	0	0.8
Pseudothecosomata	0	0	90	0	0	1.8

Chaetognatha. As apparent from our earlier reports based on these samples, chaetognaths constitute a significant share of the total zooplankton biomass in the upper 1000 m. The genus *Sagitta* was obviously predominant and was 96% and 86%, respectively, of the numbers and biomass of chaetognath standing crop. The principal species (Table 7) numerically were *S. enflata* (10.9%), *S. minima* (8.1%) and *S. serratodentata* (7.4%), the remaining species individually constituting less than 3% of total chaetognaths. These three species were also the major contributors to biomass (*S. enflata:* 40.3%, *S. serratodentata:* 10.7%; *S. minima:* 6.9%). Many of the smaller, immature chaetognaths, however, proved difficult to resolve taxonomically and the category of *Sagitta* spp. constituted 66% of the numbers and 21% of the biomass of this group. Diurnal patterns of abundance in the upper 25 m varied considerably from species to species (Table 8). Among the more numerous shallow dwelling species *Pterosagitta draco, Sagitta bipunctata, S. hexaptera* and *S. serratodentata* were noticeably more abundant in night than day in collections in the 0-25 m zone whereas the opposite obtained for *S. enflata* and *S. minima*. All species but two were more abundant in the epipelagic layer (0-200 m) than in the deeper zones sampled. The two exceptions, *E. flowleri* and *S. macrocephala* were taken at depths greater than 200 m. No strong seasonal patterns were obvious (Table 9), the distributions ranging from rather even from cruise to cruise (e.g., *S. serratodentata)* to occurring in samples of only one of the five cruises listed (e.g., *S. bipunctata*).

Table 7. Average abundance of chaetognath species in the upper 1000 m at the OTEC station off Tampa Bay

Taxon	No./m^2	%	mg dry wt/m^2	%
Sagitta spp.	2270.2	65.9	259	21.4
S. enflata	374.6	10.9	489	40.3
S. minima	280.4	8.1	84	6.9
S. serratodentata	253.6	7.4	130	10.7
S. decipiens	71.6	2.1	<9	0.4
Pterosagitta draco	54.8	1.6	9	0.7
Krohnitta subtilis	53.8	1.6	66	5.4
Krohnitta spp.	31.2	0.9	28	2.3
Sagitta hexaptera	20.2	0.6	48	4.0
S. macrocephala	11.0	0.3	9	0.4
Eukrohnia spp.	7.0	0.2	40	3.3
Sagitta bipunctata	6.2	0.2	12	1.0
S. lyra	4.8	0.1	28	2.3
Eukrohnia fowleri	1.6	+	10	0.8

Table 8. Abundance of chaetognath species per $10^4 m^3$ and under a square meter for the upper 1000 m for the period June 13, 1978 to April 29, 1979, excluding October 26, 1978 data.

Taxon	Night 0-25m	Day 0-25m	Day 0-200m	Day 200-800m	Day 800-1000m	Day $\#/m^2$
Eukrohnia fowleri	0	0	0	22	14	1.6
Eukrohnia spp.	144	0	0	110	8	7.0
Krohnitta subtilis	0	0	2114	342	100	53.8
Krohnitta spp.	9240	4100	1566	0	0	31.2
Pterosagitta draco	9610	3074	2750	2	0	54.8
Sagitta bipunctata	4318	1454	310	0	0	6.2
S. decipiens	0	0	2568	330	26	71.6
S. enflata	70456	116770	60494	58	14	374.8
S. hexaptera	642	0	952	10	12	20.2
S. lyra	0	0	88	48	4	4.8
S. macrocephala	0	0	0	154	88	11.0
S. minima	47478	83548	32446	86	0	280.4
S. serratodentata	51346	7692	34106	112	168	253.6
Sagitta spp.	204190	161314	130280	1738	988	2270.2

Table 9. Abundance of Chaetognath species under a square meter for the upper 1000 m for individual cruises to the OTEC site.

Taxon	June 1978	August 1978	December 1978	February 1979	April 1979
Eukrohnia fowleri	5	1	1	0	1
Eukrohnia spp.	21	1	3	6	4
Krohnitta subtilis	42	111	76	52	43
Krohnitta spp.	32	0	0	0	124
Pterosagitta draco	32	234	0	10	0
Sagitta bipunctata	0	0	0	0	31
S. decipiens	219	89	14	15	21
S. enflata	1164	116	118	0	476
S. hexaptera	1	36	21	10	33
S. lyra	0	4	10	10	< 1
S. macrocephala	44	2	1	2	6
S. minima	25	971	1	585	6
S. serratodentata	247	367	274	98	282
Sagitta spp.	5611	419	1283	630	3408

Thaliacea. The salp community at the OTEC station was not especially diverse and a significant share of the species found there (e.g., *Doliolum*) are closely related. Six species were positively identified (Table 10), the most numerous being *Thalia democratica* (32.9%) and *Salpa fusiformis* (9.8%). The most abundant thaliacean category, however, was *Doliolum* spp., (42.6% of the group), which was constituted by very small and often, damaged specimens of this genus. Identified doliolids, i.e., *D. denticulum, D. intermedium* and *D. gegenbauri,* ranged in abundance from 2.1 to 2.4% of the thaliacean population. In terms of biomass the above two salp species were clearly dominant, *S. fusiformis* and *T. democratica,* respectively contributing 64.7% and 12.6% of total thaliacean biomass. The principal doliolid species was *D. intermedium* which was 2.5% of total thaliacean standing crop. Again, many of the thaliaceans were small and difficult to identify, consequently 15% of the biomass remained unresolved to species.

There is evidence of diurnal vertical migration in some thaliacean species found at this station (Table 11). While not especially apparent in *S. fusiformis, Iasis zonaria, D. intermedium* and *D. gegenbauri,* night collections from the 0-25 m zone of *T. democratica* and *D. denticulatum* were much the larger. With the exception of *Salpa maxima,* all species of thaliaceans identified here were essentially epipelagic (0-200 m) in occurrence. *S. maxima* was found only in the 200-800 m zone. *Pyrosoma* colonies were relatively scarce in plankton net catches and were observed in aliquots only in the February 1979 collections. In this group, as in the others treated here, sharp seasonal trends could not be identified (Table 12).

Table 10. Average abundance of thaliacean species in the upper 1000 m at the OTEC station off Tampa Bay. + = <0.1%

Taxon	No./m^2	%	mg dry wt/m^2	%
Doliolum spp.	140.2	42.6	29	9.1
Thalia democratica	108.4	32.9	40	12.6
Salpa fusiformis	32.4	9.8	206	64.7
Salpidae	17.8	5.4	17	5.3
Doliolum (doliolum) denticulum	7.8	2.4	2	0.7
D. (doliolina) intermedium	7.4	2.2	8	2.5
D. (doliotetta) gegenbauri	7.0	2.1	4	1.3
D. (doliotetta) spp.	6.4	1.9	2	0.7
Salpa maxima	1.2	0.4	8	2.5
D. (doliolina) spp.	0.6	0.2	<1	+
Pyrosoma spp.	0.2	<0.1	2	0.7

Table 11. Abundance of thaliacean species per $10^4 m^3$ and under a square meter for the upper 100 m for the period June 13, 1978 to April 29, 1979, excluding October 26, 1978 data.

Taxon	Night 0-25m	Day 0-25m	Day 0-200m	Day 200-800m	Day 800-1000m	Day $\#/m^2$
Salpidae						
Iasis zonaria	0	284	0	0	0	0
Salpa fusiformes	2808	2060	568	184	104	32.4
S. maxima	0	0	0	20	0	1.2
Thalia democratica	22828	8194	5188	174	116	108.4
Salpidae	27864	9570	758	44	12	17.8
Doliolidae						
Doliolum (doliolum) denticulum	9694	1720	358	8	2	7.8
D. (doliolетta) gegenbauri	26	232	290	16	2	7.0
D. (doliolетta) spp.	14	0	316	0	0	6.4
D. (doliolina) intermedium	288	0	354	4	0	7.4
D. (doliolina) spp.	3176	0	0	0	32	0.6
Doliolum spp.	4390	6140	7562	36	58	140.2
Pyrosomidae						
Pyrosoma spp.	0	0	0	2	0	0.2

Table 12. Abundance of species of thaliaceans under a square meter for the upper 1000 m for individual cruises to the OTEC site.

Taxon	June 1978	August 1978	December 1978	February 1979	April 1979
Salpidae					
Salpa fusiformes	0	0	5	11	146
S. maxima	0	0	0	6	0
Thalia democratica	2	2	155	35	348
Salpidae (Unident.)	0	0	14	4	71
Doliolidae					
Doliolum (doliolum) denticulum	4	0	19	15	0
D. (dolioletta) gegenbauri	12	5	0	10	8
D. (dolioletta) spp.	0	0	0	32	0
D. (doliolina) intermedium	10	7	10	10	0
D. (doliolina) spp.	0	0	3	0	0
Doliolum spp.	37	25	52	331	256
Pyrosomidae					
Pyrosoma spp. (colony)	0	0	0	1	0

Euphausiacea. Euphausiids rank high in the composition of zooplankton standing crop in the upper 1000 m at the OTEC site (see earlier OTEC reports). Sixteen species were identified from six genera (Table 13) and the principal species numerically were *Euphausia tenera* (11.8%), *Nematoscelis atlantica* (5.5%) and *N. microps* (5.3%). All other species were less than 4% of euphausiid numbers. In terms of biomass the principal species in the upper 1000 m were *N. atlantica* (10.7%), *E. tenera* (7.3%), *Nematobrachion boopis* (5.7%; rare but large) and *E. americana* (4.3%). The remaining species were individually less than 4% of total euphausiid standing crop. Immatures were often difficult to identify, consequently 61% of euphausiid numbers and 32% of their biomass were not resolved taxonomically to species.

Diurnal vertical movement into the upper 25 m at night was strongly reflected in data for the genus *Euphausia*, *E. tenera* and *E. americana* in particular (Table 14). *Stylocheiron* characteristically showed little movement into this shallow zone at night, with the possible exception of *S. carinatum*. Of all the groups considered here, the euphausiids demonstrated the greatest diel vertical range, this again being especially apparent in the genus *Euphausia*. Considering the available daytime data, *Euphausia*, *Nematoscelis* and *Nematobrachion* were found mostly below 200 m while the relatively non-migratory *Stylocheiron* generally remained in the epipelagic layer (with the possible exceptions of *S. elongatum* and *S. longicorne*). *Thysanopoda* were comparatively scarce. *T. monocantha* was mostly in the 0-200 m zone whereas the much rarer *T. orientalis* was restricted to collections from the intermediate 200-800 m zone. Because of sample size restrictions little can be stated on seasonality in abundance of individual species of euphausiids (see Table 15).

Table 13. Average abundance of euphausiid species in the upper 1000 m at the OTEC station off Tampa Bay.

Taxon	No./m^2	%	mg dry wt/m^2	%
Unident. Euphausiids (immat.)	48.4	31.1	49	11.1
Stylocheiron spp.	26.0	16.7	37	8.4
Euphausia spp.	19.4	12.5	37	8.4
E. tenera	18.4	11.8	32	7.3
Nematoscelis atlantica	8.6	5.5	47	10.7
N. microps	8.2	5.3	94	21.3
Euphausia americana	5.2	3.3	19	4.3
Stylocheiron suhmii	3.0	1.9	7	1.6
S. longicorne	2.8	1.8	7	1.6
Thysanopoda monocantha	2.8	1.8	14	3.2
Euphausia hemigibba	2.2	1.4	15	3.4
Stylocheiron elongatum	2.2	1.4	10	2.3
S. carinatum	2.0	1.3	7	1.6
Euphausia mutica	1.8	1.2	5	1.1
Nematoscelis spp.	1.6	1.0	20	4.5
Stylocheiron affine	1.2	0.8	3	0.7
S. abbreviatum	0.8	0.5	4	0.9
Nematobrachion boopis	0.6	0.4	25	5.7
Stylocheiron maximum	0.2	0.1	1	0.2
Thysanopoda orientalis	0.2	0.1	8	1.8

Table 14. Abundance of euphausiid species per $10^4 m^3$ and under a square meter for the upper 1000 m for the period June 13, 1978 to April 29, 1979, excluding October 26, 1978 data.

Taxon	Night 0-25m	Day 0-25m	Day 0-100m	Day 200-800m	Day 800-1000m	Day $\#/m^2$
Euphausia americana	1002	0	0	82	10	5.2
E. hemigibba	634	0	0	28	16	2.2
E. mutica	164	0	0	28	0	1.8
E. pseudogibba	14	0	0	0	0	0
E. tenera	7372	0	0	296	44	18.2
Euphausia spp.	4842	28	222	244	16	19.4
Nematobrachion boopis	0	0	0	6	8	0.6
Nematoscelis atlantica	124	0	0	160	10	8.6
N. microps	0	0	0	134	12	8.2
Nematoscelis spp.	0	0	0	24	8	1.6
Stylocheiron abbreviatum	0	38	44	0	0	0.8
S. affine	194	150	62	0	0	1.2
S. carinatum	172	0	104	0	0	2.0
Stylacheiron elongatum	0	0	20	26	0	2.2
S. longicorne	0	0	0	144	0	2.8
S. maximum	0	38	10	0	0	0.2
S. suhmii	90	0	116	0	0	3.0
Stylocheiron spp.	2272	2302	1190	32	30	26.0
Thysanopoda monacantha	0	0	110	8	0	2.8
T. orientalis	0	0	0	2	0	0.2
Euphausiaceae	3348	10670	1754	182	20	48.4

Table 15. Abundance of euphausiid species under a square meter for the upper 1000 m for individual cruises to the OTEC site.

Taxon	June 1978	August 1978	December 1978	February 1979	April 1979
Euphausia americana	8	0	6	4	8
E. hemigibba	2	4	0	1	4
E. mutica	0	2	0	3	0
E. tenera	21	10	14	34	12
Euphausia spp.	23	2	8	54	10
Nematobrachion boopis	0	0	3	0	0
Nematoscelis atlantica	12	15	2	6	8
N. microps	16	2	4	6	8
Nematoscelis spp.	7	0	0	0	1
Stylocheiron abbreviatum	0	0	1	0	0
S. affine	2	0	0	4	0
S. carinatum	6	5	0	0	0
S. elongatum	2	5	2	4	0
S. longicorne	6	0	6	2	0
S. maximum	0	0	0	1	0
S. suhmii	2	4	7	2	0
Stylocheiron spp.	30	36	2	51	11
Thysanopoda monacantha	0	0	13	1	0
T. orientalis	0	0	0	1	0
Euphausiaceae (Unident.)	161	33	23	15	0

Amphipoda. This group, while not conspicuously abundant, was species rich. Amphipods, however, proved difficult to identify, which was particularly the case for the immature stages. Even so, 23 species were resolved (Table 16), the most numerous being *Primno macropa* (16.7%), *Eusirus longipes* (9.5%; a gammarid), *Phronimopsis spinifera* (3.7%), *Hyperoides longipes* (2.4%), *Phronimella elongata* (1.3%), *Phrosina semilunata* (1.3%), and *phronima colleti* (1.1%). All other species individually were less than 1%. The biomass dominants were *Eusirus longipes* (34.2%), *Primno macropa* (18.8%), *Hyperiodes longipes* (3.4%), *Rhabdosoma minor* (1.7%), *Phronimella elongata* (1.7%), *Parapronoe crustulum* (1.7%), and *Scina rattrayi* (1.7%). The remainder were individually less than 1% of the standing crop.

Because of their relative scarcity and the small volume of water sampled, little can be said concerning cruise-to-cruise fluctuation (Table 17). Only *Primno macropa* was found in collections from all seven cruises. Also, too few amphipods were taken to meaningfully compare day and night abundances. During the day at least, the time period for which the data are more complete, most species appear to be epipelagic, being taken primarily in the upper 200 m (Table 18).

Table 16. Average abundance of amphipod species in the upper 1000 m at the OTEC station off Tampa Bay. + = <1 mg or <0.1%

Taxon	No./m^2	%	mg dry wt/m^2	%
Hyperiids (unident.)	25.0	23.2	10	8.5
Primmo macropa	18.0	16.7	22	18.8
Hyperia spp.	14.6	13.5	8	6.8
Hyperiidae (unident.)	14.2	13.2	5	4.2
Eusirus longipes	10.2	9.5	40	34.2
Phronimopsis spinifera	4.0	3.7	+	+
Scina spp .	3.8	3.5	8	6.8
Hyperoides longipes	2.6	2.4	4	3.4
Platyscelus spp.	1.6	1.5	2	1.7
Phronimella elongata	1.4	1.3	2	1.7
Phrosina similunata	1.4	1.3	1	0.9
Phronima colletti	1.2	1.1	+	+
Streetsia porcella	1.0	0.9	+	+
Eupronoe spp.	1.0	0.9	1	0.9
Vibilia spp.	0.8	0.7	1	0.9
Paraphronima gracilis	0.6	0.6	+	+
Streetsia challengeri	0.6	0.6	+	+
Parapronoe crustulum	0.6	0.6	2	1.7
Gammarids (unident.)	0.6	0.6	+	+
Brachyscelus crusculum	0.4	0.4	1	0.9
Lycaeopsis thermistoides	0.4	0.4	1	0.9
Anchylomera blossevillei	0.4	0.4	+	+
Eupronoe intermedia	0.4	0.4	+	+
E. maculata	0.4	0.4	1	0.9
Pronoe capito	0.4	0.4	1	0.9
Pronoidae (unident.)	0.4	0.4	+	+
Vibilia stebbingi	0.4	0.4	+	+
Eusirus spp.	0.4	0.4	2	1.7
Hyperoche spp.	0.2	0.2	+	+
Lanceola spp.	0.2	0.2	+	+
Rhabdosoma minor	0.2	0.2	2	1.7
Paraphronima crassipes	0.2	0.2	+	+

Table 16 (Cont'd.). Average abundance of amphipod species in the upper 1000 m at the OTEC station off Tampa Bay.

Taxon	No./m^2	%	mg dry wt/m^2	%
Paratyphus spp.	0.2	0.2	+	+
Scina rattrayi	0.2	0.2	2	1.7
Cyllopus magellanicus	0.2	0.2	+	+
Vibilia viatrix	0.2	0.2	1	0.9

Table 17. Abundance of amphipod species under a square meter for the upper 1000 m for individual cruises to the OTEC site.

Taxon	June 1978	August 1978	December 1978	February 1979	April 1979
Hyperiidea					
Brachyscelidae					
Brachyscelus crusculum	0	0	0	0	2
Hyperiidae					
Hyperia spp.	41	7	1	15	9
Hyperoche spp.	0	0	0	1	0
Hyperoides longipes	9	4	0	0	0
Parathemisto spp.	14	0	0	0	0
Phronimopsis spinifera	14	0	0	6	0
Hyperiidae (unident.)	30	14	11	16	0
Lanceolidae					
Lanceola spp.	0	0	1	0	0
Lycaeopsidae					
Lycaeopsis thermistoides	2	0	0	0	0
Oxycephalidae					
Rhabdosoma minor	0	0	0	1	0
Streetsia challengeri	2	0	0	1	0
S. porcella	0	0	0	5	0
Paraphronimidae					
Paraphronima crassipes	0	0	1	0	0
P. gracilis	2	0	0	1	0
Phronimidae					
Phronima atlantica	4	0	0	0	0
P. colletti	0	0	1	5	0
Phronimella elongata	4	0	0	1	2
Phrosinidae					
Anchylomera blossevillei	0	0	0	1	0
Phrosina semilunata	0	0	1	6	0
Primno macropa	26	5	14	10	24
Platyscelidae					
Platyscelus spp.	0	7	1	0	0
Paratyphus spp.	0	0	1	0	0

Table 17. (Cont'd.)

Taxon	June 1978	August 1978	December 1978	February 1979	April 1979
Hyperiidea					
Pronoidae					
Eupronoe intermedia	2	0	0	0	0
Eupronoe maculata	0	0	0	0	2
Eupronoe spp.	4	0	0	1	0
Parapronoe crustulum	0	0	2	1	0
Pronoe capito	0	0	0	0	2
Pronoidae (unident.)	2	0	0	0	0
Sciniidae					
Scina rattrayi	0	0	0	0	1
Scina spp.	5	6	4	2	2
Vibiliidae					
Cyllopus magellanicus	0	0	0	0	1
Scina stebbingi	2	0	0	0	0
Vibilia viatrix	1	0	0	0	0
Vibilia spp.	0	2	0	0	2
Hyperiidea (unident.)	68	4	9	25	19
Gammaridea					
Eusiridae					
Eusirus longipes	48	0	1	3	0
Eusirus spp.	0	2	0	0	0
Gammarids (unident.)	2	0	1	0	0

Table 18. Abundance of amphipod species per $10^4 m^3$ and under a square meter for the upper 1000 m for the period June 13, 1978 to April 29, 1979, excluding October 26, 1978 data.

Taxon	Night 0-25m	Day 0-25m	Day 0-200m	Day 200-800m	Day 800-1000m	Day $\#/m^2$
Hyperiidea						
Brachyscelidae						
Brachyscelus crusculum	48	0	20	0	0	0.4
Hyperiidae						
Hyperia spp.	2006	172	676	6	20	14.6
Hyperoche spp.	0	0	0	2	0	0.2
Hyperoides longipes	0	0	80	32	0	2.6
Parathemisto spp.	228	116	0	0	0	0
Phronimopsis spinfera	84	0	194	2	0	4.0
Hyperiidae (unident.)	500	5838	450	84	12	14.2
Lanceolidae						
Lanceola serrata	0	0	0	0	2	<.1
Lanceola spp.	0	0	12	0	0	0.2
Lycaeidae						
Lycaea pulex	48	0	0	0	0	0
L. serrata	0	38	0	0	0	0
Lycaea spp.	14	0	0	0	0	0
Lycaeopsidae						
Lycaeopsis thermistoides	72	0	0	6	0	0.4
Oxycephalidae						
Oxycephalus clausi	0	0	0	0	0	0
Rhabdosoma brevicaudatum	322	0	0	0	0	0
R. minor	0	0	10	0	0	0.2
R. whitei	14	10	0	0	0	0
Streetsia challengeri	132	16	30	0	0	0.6
S. porcella	62	38	64	0	0	1.0
S. steenstrupi	30	0	0	0	0	0
Paraphronimidae						
Paraphronima crassipes	0	0	0	0	12	0.2
P. gracilis	56	0	10	6	0	0.6

Table 18 (Cont'd.)

Taxon	Night 0-25m	Day 0-25m	Day 0-100m	Day 200-800m	Day 800-1000m	Day $\#/m^2$
Phronimidae						
Phronima atlantica	254	0	40	0	0	4.0
P. colletti	218	26	62	0	0	1.2
P. sedentaria	48	0	0	0	0	0
Phronima spp.	48	80	0	0	0	0
Phronimella elongata	700	444	70	0	0	1.4
Phrosinidae						
Anchylomera blossevillei	212	54	22	0	0	0.4
Phrosina semilunata	266	1102	74	0	0	1.4
Primno macropa	308	1578	714	56	22	18.0
Platyscelidae						
Amphithyrus bispinosus	10	0	0	0	0	0
Parathyphus spinosus	0	20	0	0	0	0
Paratyphus spp.	132	0	12	0	0	0.2
Platyscelus spp.	86	0	78	0	0	1.6
Platyscelidae	104	290	0	0	0	0
Pronoidae						
Eupronoe intermedia	40	30	20	0	0	0.4
E. maculata	0	0	20	0	0	0.4
Eupronoe spp.	224	248	50	0	0	1.0
Paralycaea gracilis	48	0	0	0	0	0
Pronoidae						
Parapronoe crustulum	10	0	24	2	0	0.6
Pronoe capito	0	0	20	0	0	0.4
Pronoe spp.	48	0	0	0	0	0
Pronoidae (unident.)	40	0	0	6	0	0.4
Scinidae						
Ctenoscina brevicaudatum	14	0	0	0	0	0
Scina rattrayi	0	0	0	4	0	0.2
Scina spp.	10	0	62	52	26	3.8

Table 18 (Cont'd.)

Taxon	Night 0-25m	Day 0-25m	Day 0-100m	Day 200-800m	Day 800-1000m	Day $\#/m^2$
Vibiliidae						
Cyllopus magellanicus	0	0	0	4	0	0.2
Vibilia stebbingi	0	0	0	0	16	0.4
V. viatrix	28	0	0	0	8	0.2
Vibilia spp.	186	0	22	8	0	0.8
Hyperiids (unident.)	3666	696	1072	54	18	25.0
Gammariidea						
Eusiridae						
Eusirus longipes	14	0	132	128	6	10.2
Eusirus spp.	0	0	0	6	0	0.4
Gammarids (unident.)	0	0	32	0	0	0.6

DISCUSSION

Species composition. All of the species listed, with the possible exception of amphipods, have previously been reported from the Gulf of Mexcio, Straits of Florida or Caribbean (Moore, 1953; Lewis, 1954; Owre, 1960; Owre and Foyo, 1972; Michel and Foyo, 1976; Haagensen, 1976). The fauna at the OTEC site, then, can be considered essentially tropical-subtropical in origin. Comprehensive quantitative data such as presented here and previously (OTEC copepod data), however, are virtually unavailable for the Gulf of Mexico. The most complete data set in print wherein a wide spectrum of plankton groups has been treated is that of Michel and Foyo (1976) and Haagensen (1976) for locations in the adjacent Caribbean. As their information is not integrated over the water column nor expressed in terms of volume filtered, species quantitative and dominance patterns cannot be readily compared. Their data, as evident in ours, however, clearly indicate the quantitative importance of *Euphausia tenera, Thalia democratica, Limacina inflata* and *Sagitta enflata* within their respective groups.

Seasonal patterns. Little is known of seasonality in oceanic plankton of the Gulf of Mexico. There is some evidence for size class progressions in species of myctophids found in the eastern Gulf (Hopkins and Baird, unpublished data) and indeed, some seasonality would be predicted, at least for the shallow epipelagic fauna on the basis of Molinari and Mayer's (1980) temperature profiles. Their data show, for example, that surface temperatures can be as low as 19^{o}C in winter (February) and exceed 29^{o}C in the summer (August), the upper 50 m evidencing a considerable annual range. The population in the upper 1000 m of each group, expressed as numbers and biomass per square meter of sea surface, for each cruise date, is in Figure 1. Greatest numbers for chaetognaths, pteropods, amphipods and euphausiids were for June, 1978; though pteropods were equally abundant in December 1978. Calicophoran siphonophores had had a maximum in January, 1979 and thaliaceans in April, 1979. Biomass patterns, in general, followed those of the numerical data, with the exception of pteropods. Considering the relatively small volumes of water filtered, evidence that the maxima represent seasonal patterns is uncertain at best. Similar patterns, for instance, could also be effected by major water mass replacement at the sampling site between cruises.

Another means of assessing seasonality is through analysis of size data. In figures 2 A-F are the size distributions of the six groups plotted for each cruise. There is little apparent seasonal progression in size classes of thaliaceans and calycophorans as the maximum remains in the 2-2.9 mm fraction in every cruise for the former and in the 3-3.9 mm category for the latter group. There is, however, tentative evidence for seasonality in the other groups. In chaetognaths, the 2-2.9 and 3-3.9 mm fractions are important numerically in June, 1978 collections while they contribute proportionately far less in December, 1978 and January, 1979. Euphausiids also evidenced many small (1-1.9 mm) juveniles in the population in June, 1978, whereas proportionately, markedly fewer occurred in samples from the succeeding cruises. Amphipods in general show the same pattern as euphausiids. In pteropods, the smallest size class (<0.3 mm) was relatively strong in June, 1978 and August, 1978, but was less significant in the December and January collections. This size class re-appears in April, 1979 at which time it is the dominant fraction. These data only infer seasonality and more sampling at closer time intervals and over a

Figure 1. Standing crop of individual groups of zooplankton in the upper 1000 m at the Tampa Bay OTEC site for five cruises.

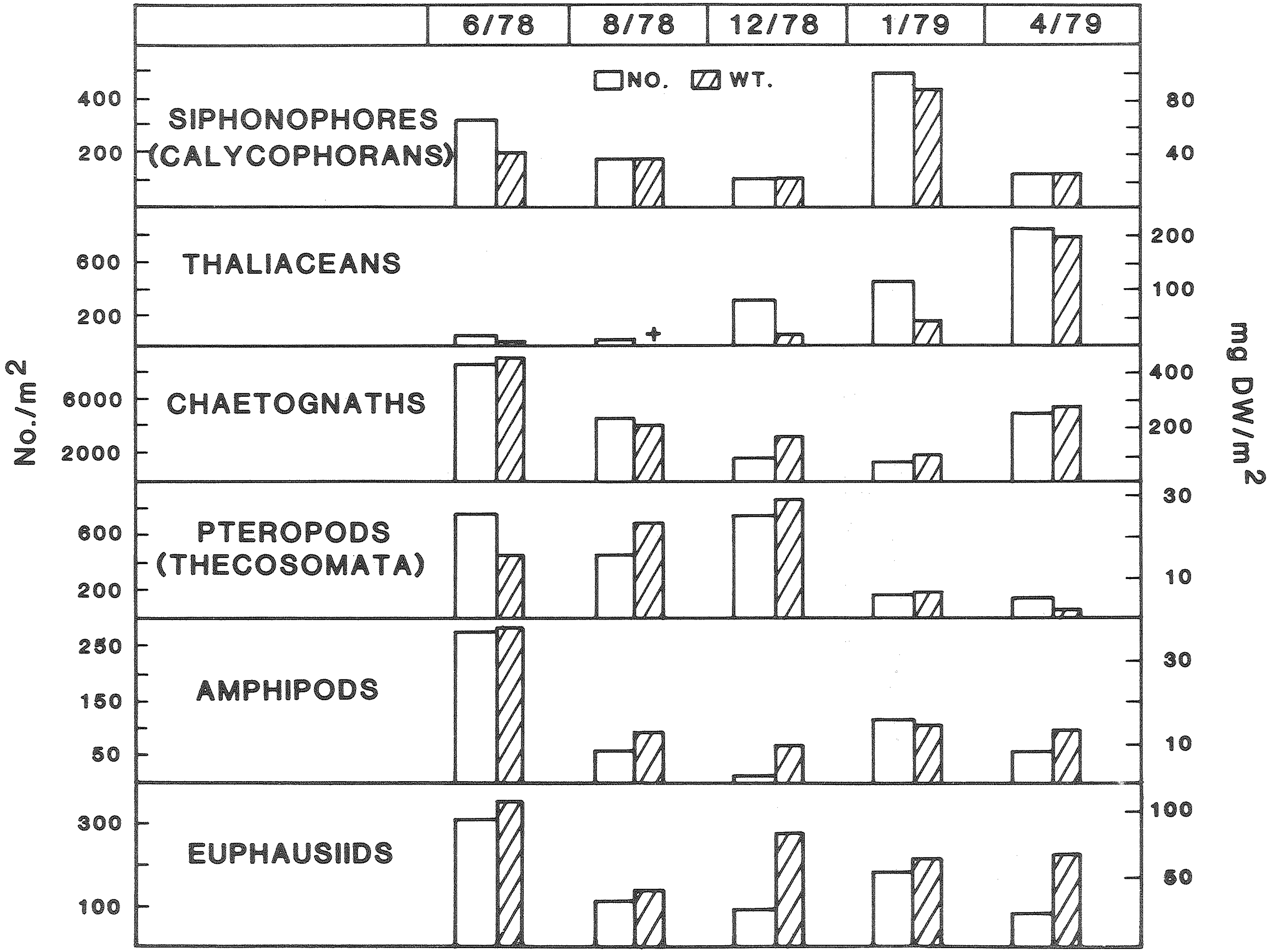
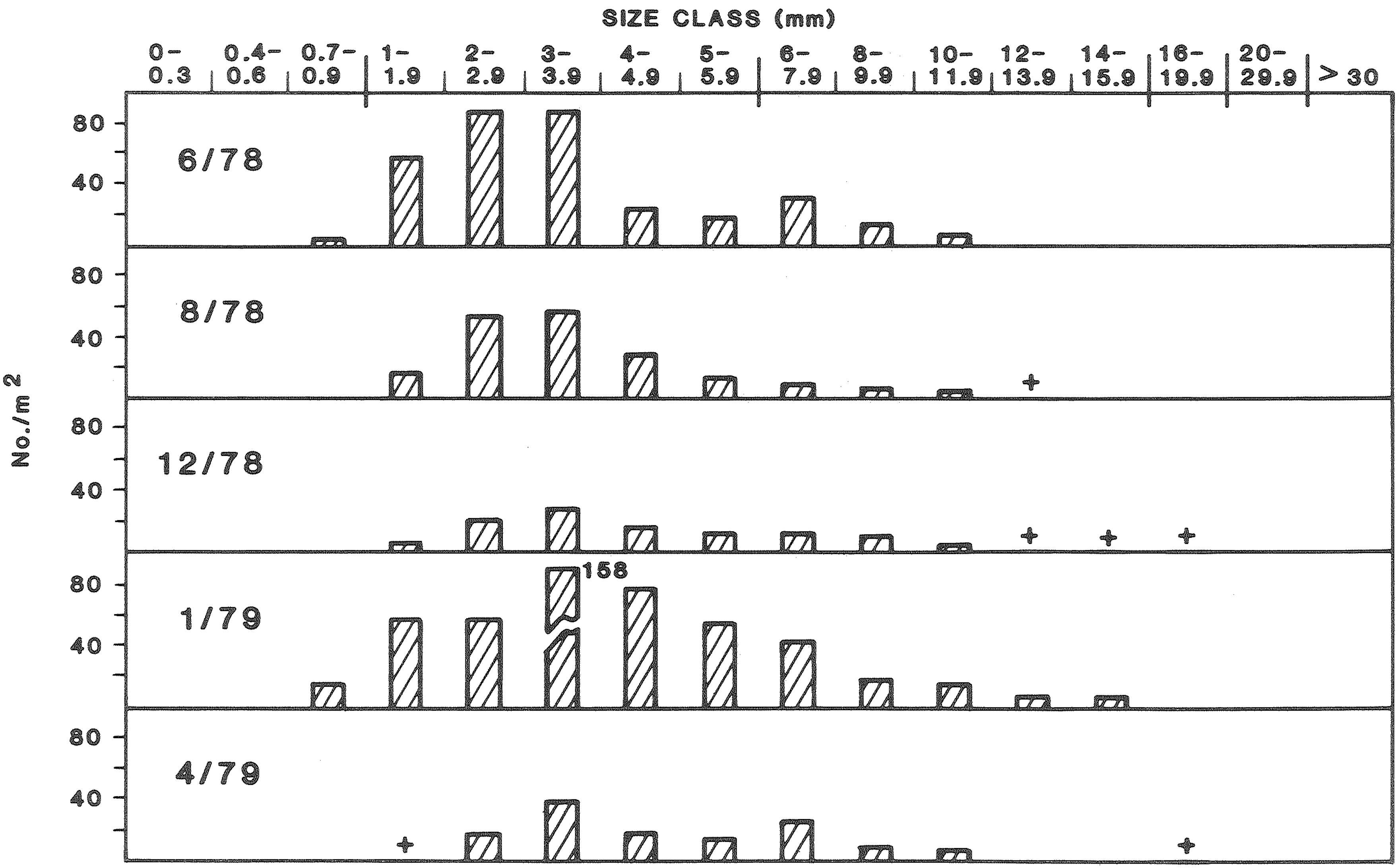
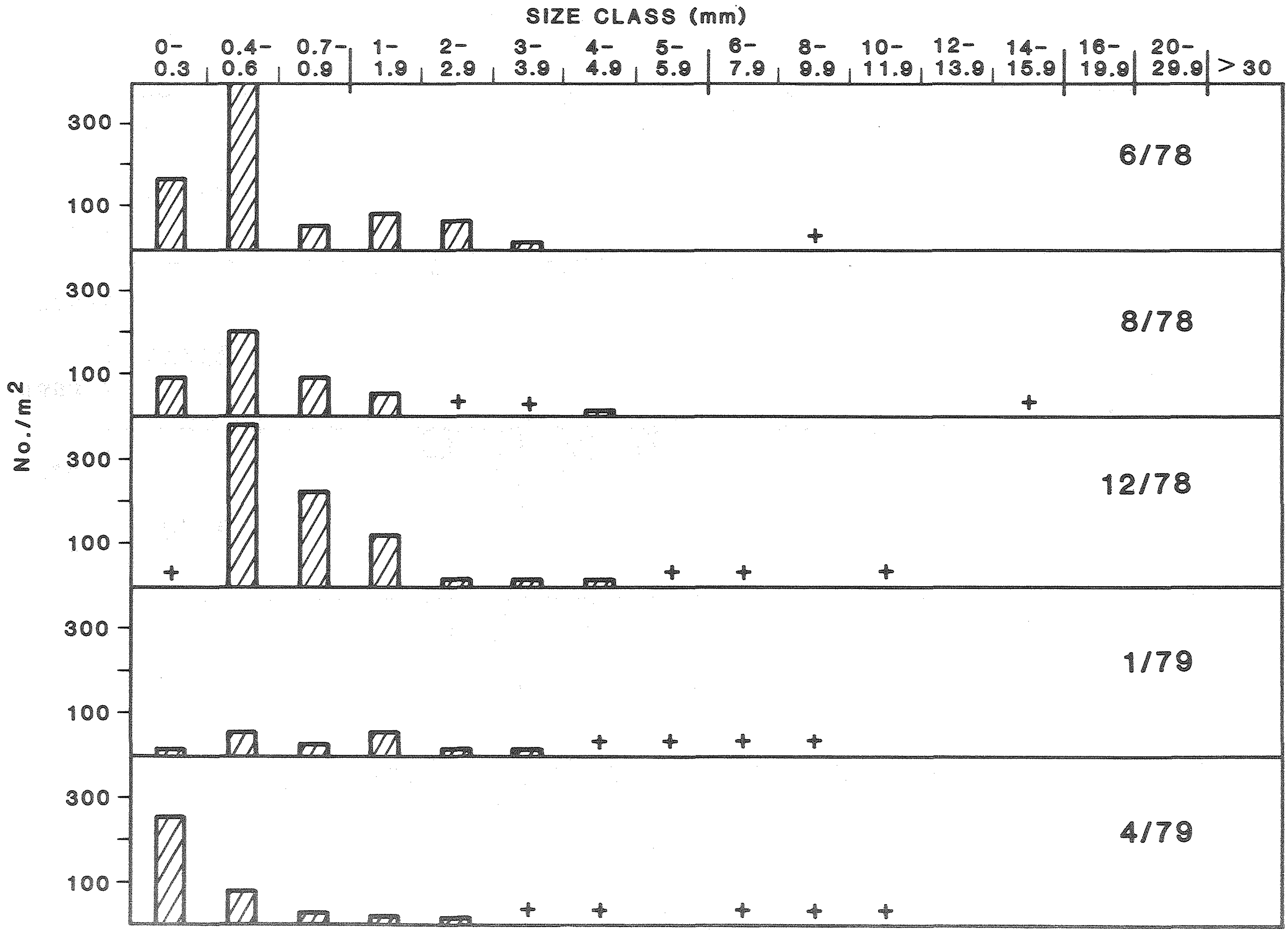

6/78
8/78
12/78
1/79
4/79
NO.
WT.
SIPHONOPHORES (CALYCOPHORANS)
THALIACEANS
CHAETOGNATHS
PTEROPODS (THECOSOMATA)
AMPHIPODS
EUPHAUSIIDS
No./m2
mg DW/m2
400
200
600
6000
2000
250
150
50
300
100
80
40
30
10

Figure 2 A-F. Size distribution in the upper 1000 m for populations of calycophoran siphonophores, shelled pteropods, chaetognaths, thaliaceans, euphausiids and amphipods taken on five cruises to the Tampa Bay OTEC site.

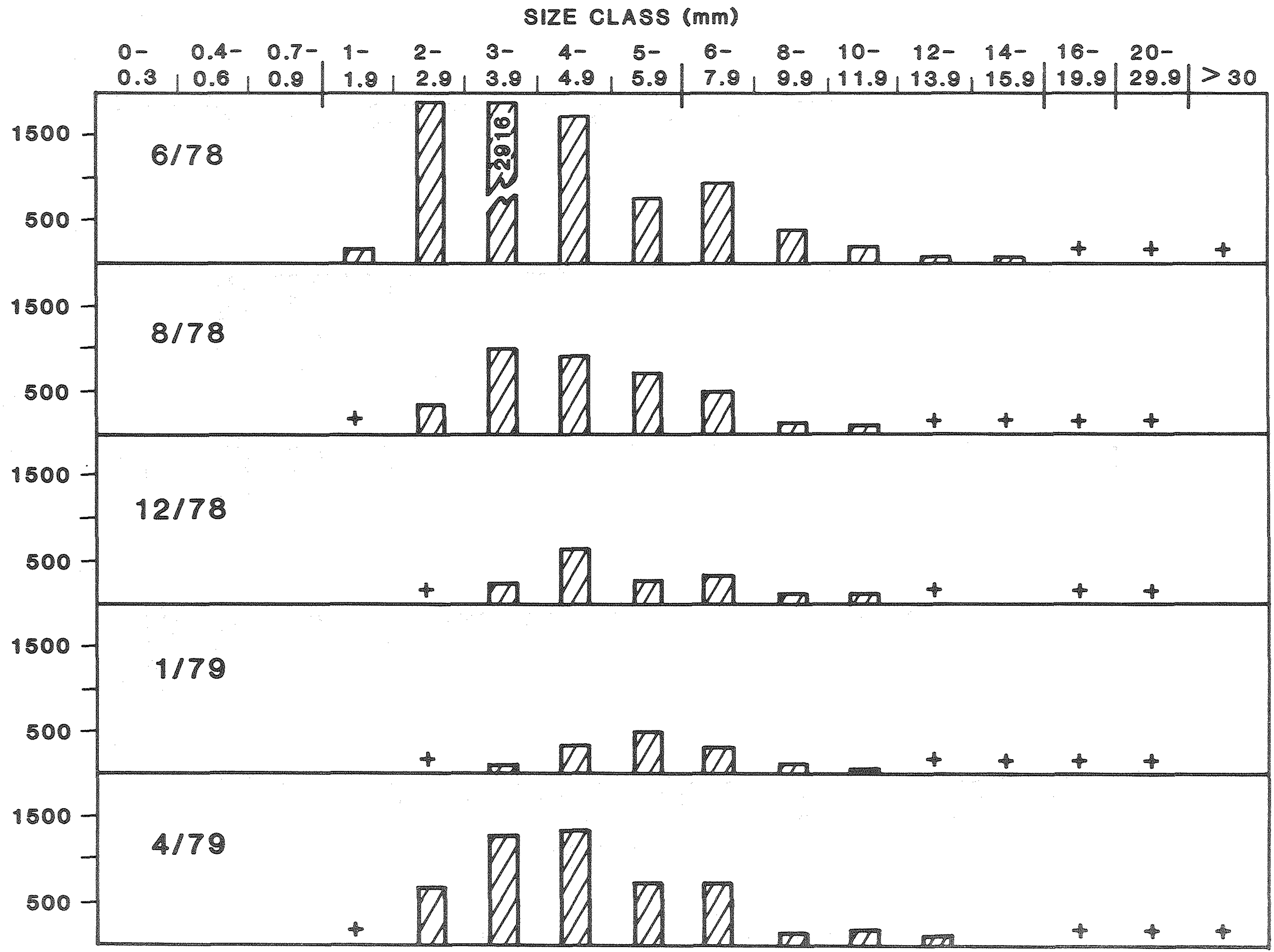
CALYCOPHORANS



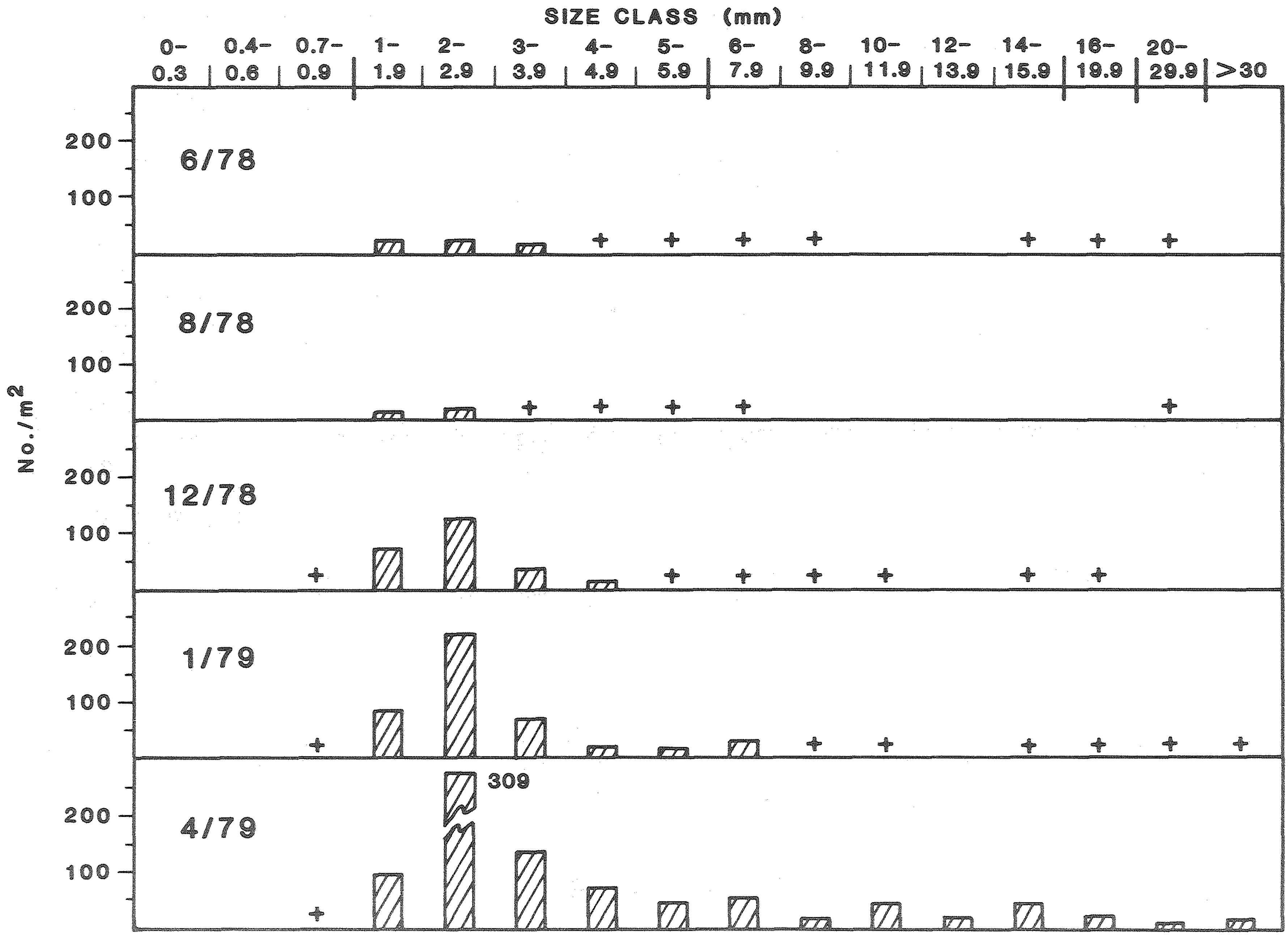
PTEROPODS (THECOSOMATA)



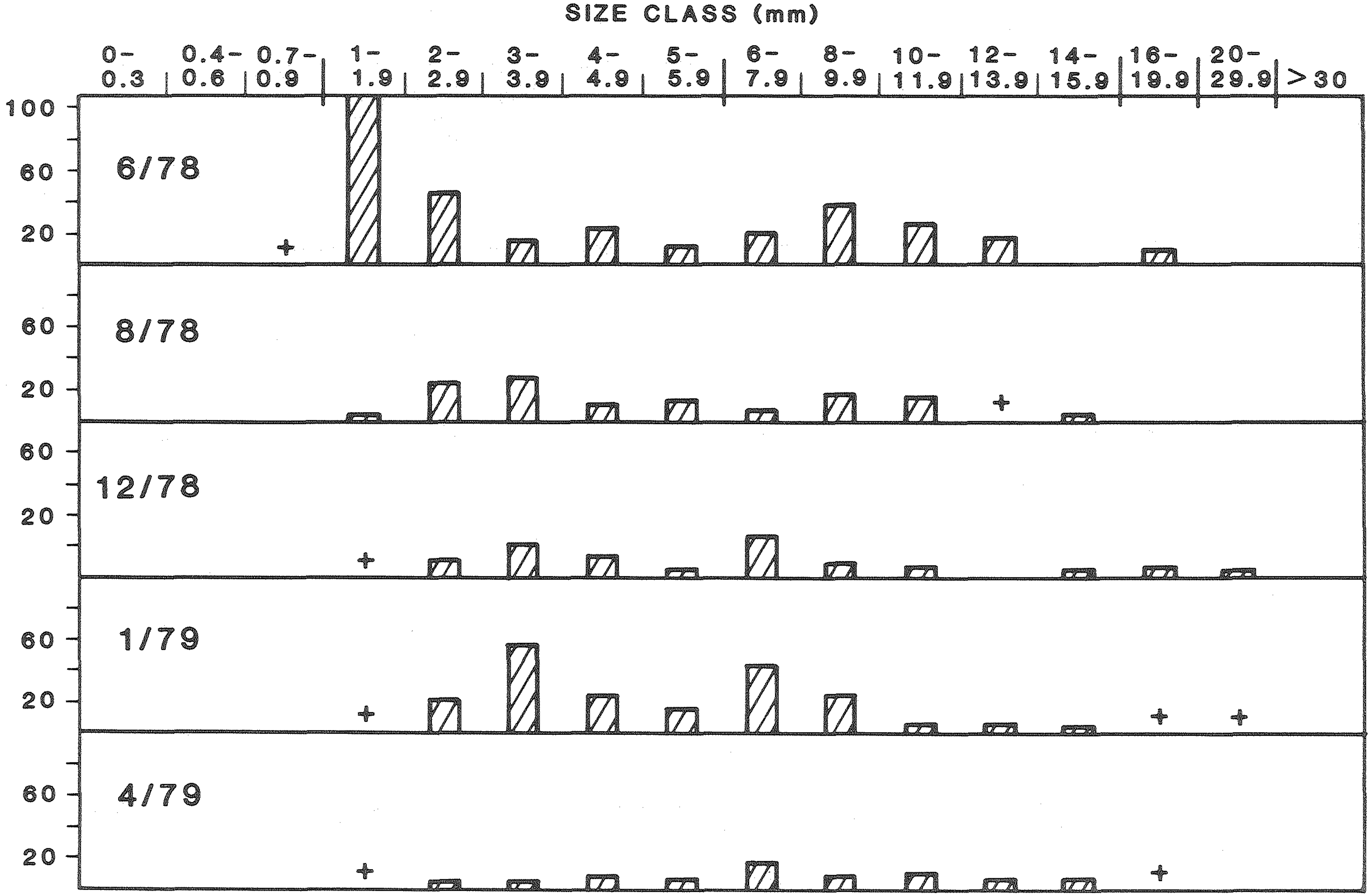
CHAETOGNATHS



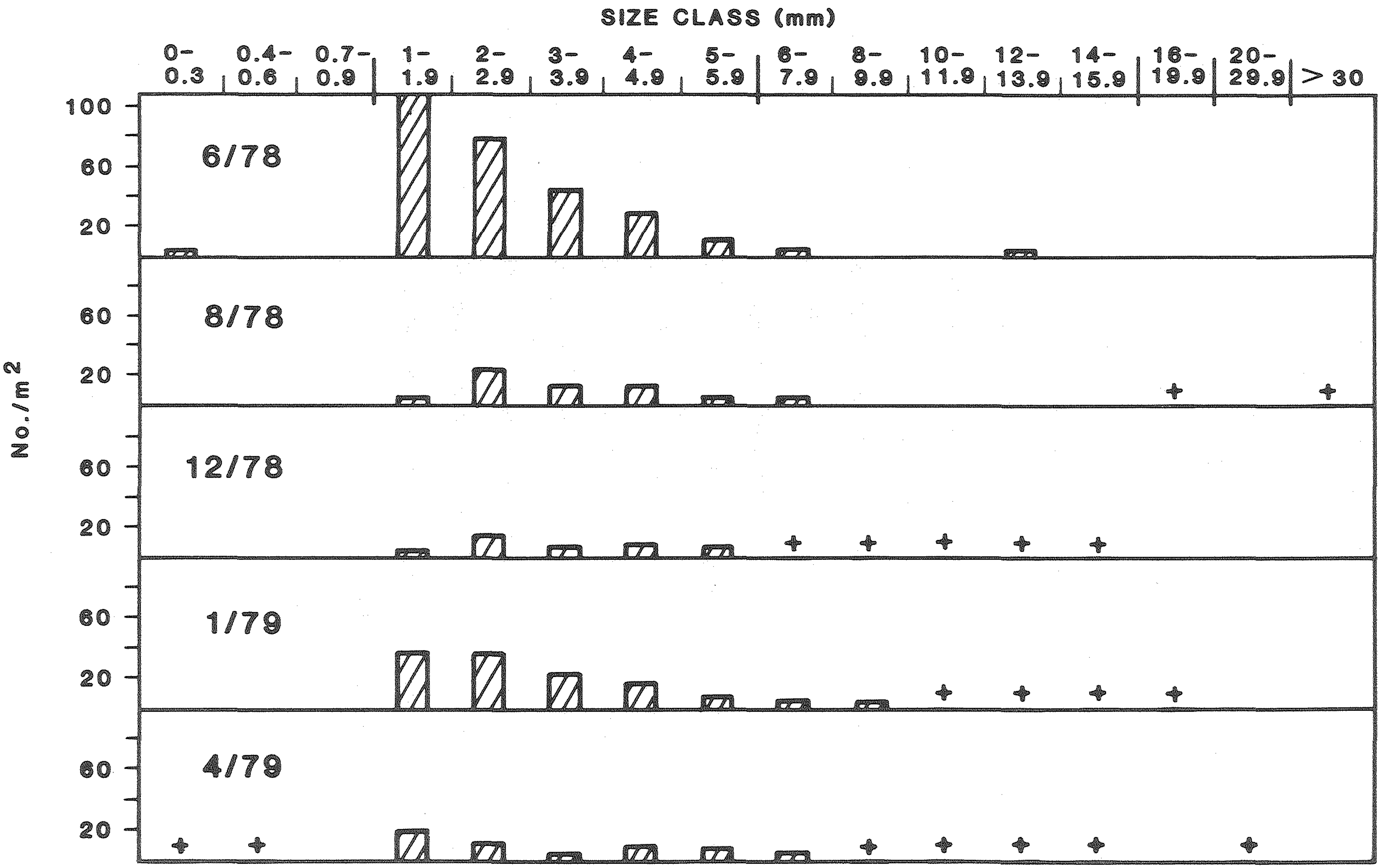
THALIACEANS



EUPHAUSIIDS



AMPHIPODS



SIZE CLASS (mm)
0-0.3
0.4-0.6
0.7-0.9
1-1.9
2-2.9
3-3.9
4-4.9
5-5.9
6-7.9
8-9.9
10-11.9
12-13.9
14-15.9
16-19.9
20-29.9
> 30
No./m^2
100
60
20
6/78
8/78
12/78
1/79
4/79

number of years is requisite to obtain more positive proof of seasonality in the oceanic plankton of the eastern Gulf.

Standing crop. The vertical distribution of standing crop in the upper 1000 m during the day of each of the six groups is in Figure 3. With but one exception, both numbers and biomass were concentrated in the upper 200 m. In the case of the exception, euphausiids, during the day numbers were greatest in the upper 200 m whereas biomass was concentrated more in the 200-800 m zone. This results from juvenile stages remaining in the epipelagic zone during the day and of adults and subadults, with greater biomass per individual, occupying the intermediate mesopelagic layers. As apparent from our data taken at 27°N 86°W some 48 km distant (Iverson and Hopkins, in press) from the OTEC site, standing crop, particularly in the upper 400 m, undergoes significant diel changes. In the present study the only diel comparisons available are for the 0-25 m layer. Considering only night/day differences in excess of $\pm 30\%$ (see Table 19), calycophoran siphonophores and thaliaceans were usually more abundant in the upper 25 m during the day than at night. Chaetognaths evidenced no particular trend whereas pteropods, amphipods and euphausiids in collections from most cruises were more abundant in this zone during the night. Of these groups the euphausiids in particular are well documented as strong diel migrators (e.g., see Lewis, 1954).

Figure 3. The vertical distribution (average of all cruises) of the six groups of zooplankton during the day in the upper 1000 m at the OTEC site off Tampa Bay.

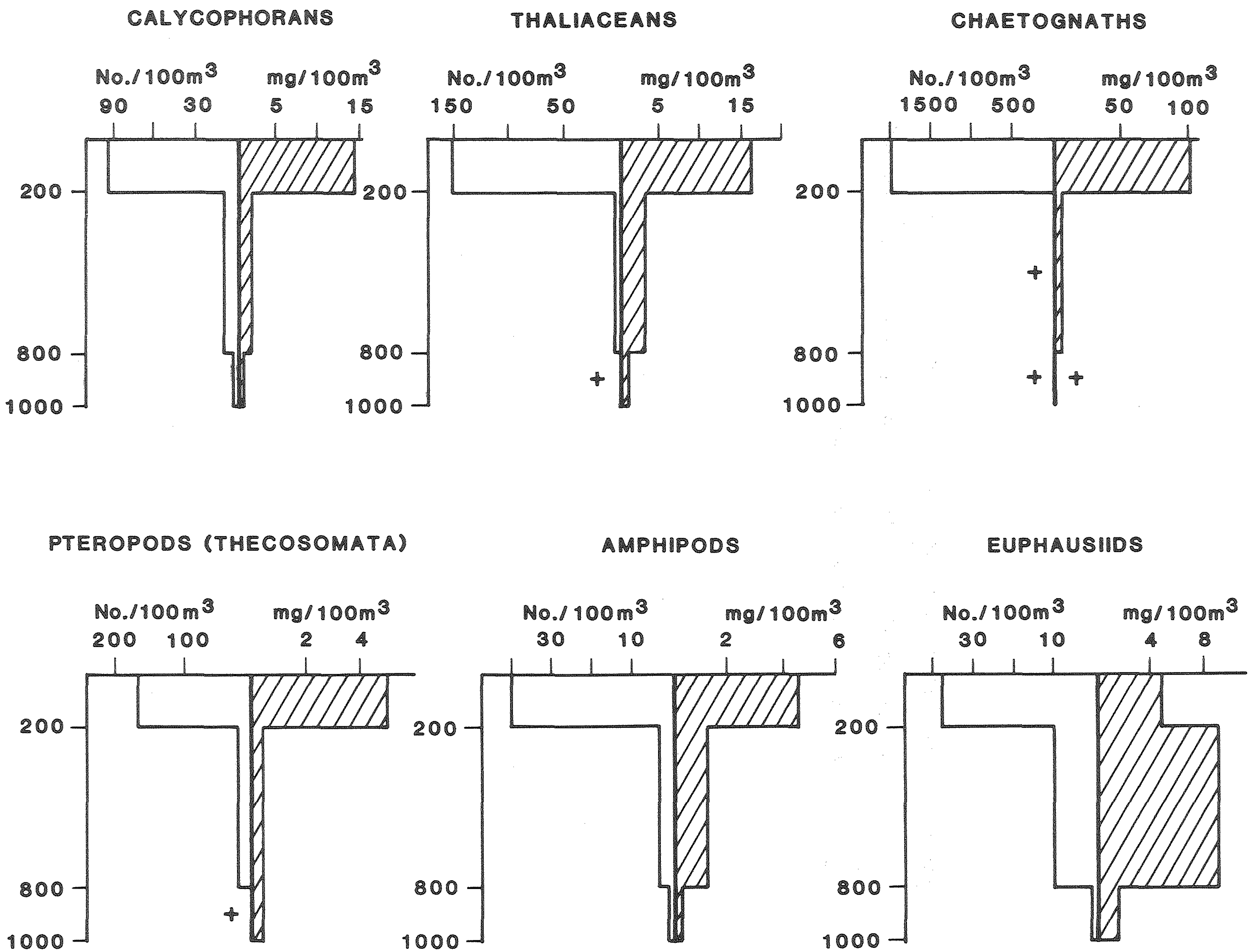

CALYCOPHORANS
No./100m3
mg/100m3
90
30
5
15
200
800
1000
THALIACEANS
No./100m3
mg/100m3
150
50
5
15
200
800
1000
+
CHAETOGNATHS
No./100m3
mg/100m3
1500
500
50
100
200
800
1000
+
+
+
PTEROPODS (THECOSOMATA)
No./100m3
mg/100m3
200
100
2
4
200
800
1000
+
AMPHIPODS
No./100m3
mg/100m3
30
10
2
6
200
800
1000
EUPHAUSIIDS
No./100m3
mg/100m3
30
10
4
8
200
800
1000

Table 19. Night/day ratios of numbers/1000 m^3 for 0-25 catches at the Tampa Bay OTEC site.

Group	6/78	8/78	10/78	DATE 12/78	2/79	4/79	6/79
Calycophoran siphonophores	0.16	1.41	0.65	0.32	0.67	1.23	1.44
Thaliaceans	0.17	0.44	0.50	3.86	4.64	0.80	0.51
Chaetognaths	0.84	2.05	1.65	0.97	0.77	1.23	0.64
Shelled pteropods	0.01	8.17	1.88	6.29	3.16	2.01	32.99
Amphipods	0.08	2.19	1.82	0.89	2.51	1.31	2.44
Euphausiids	0.04	746.00	17.00	2.47	5.57	26.53	5.16

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